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A simple quantum heat engine

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abstract Quantum heat engines employ as working agents multi-level systems instead of gas-filled cylinders. We consider particularly two-level agents such as electrons immersed in a magnetic field. Work is produced in that case when the electrons are being carried from a high-magnetic-field region into a low-magnetic-field region. In watermills, work is produced instead when some amount of fluid drops from a high-altitude reservoir to a low-altitude reservoir. We show that this purely mechanical engine may in fact be considered as a two-level quantum heat engine, provided the fluid is viewed as consisting of n molecules of weight one and $N - n$ molecules of weight zero. Weight-one molecules are analogous to electrons in their higher energy state, while weight-zero molecules are analogous to electrons in their lower energy state. More generally, fluids consist of non-interacting molecules of various weights. It is shown that, not only the average value of the work produced per cycle, but also its fluctuations, are the same for mechanical engines and quantum (Otto) heat engines. The reversible Carnot cycles are approached through the consideration of multiple sub-reservoirs.